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California's Emissions of High-GWP GHGs and Approaches for Improved Inventory and Verification

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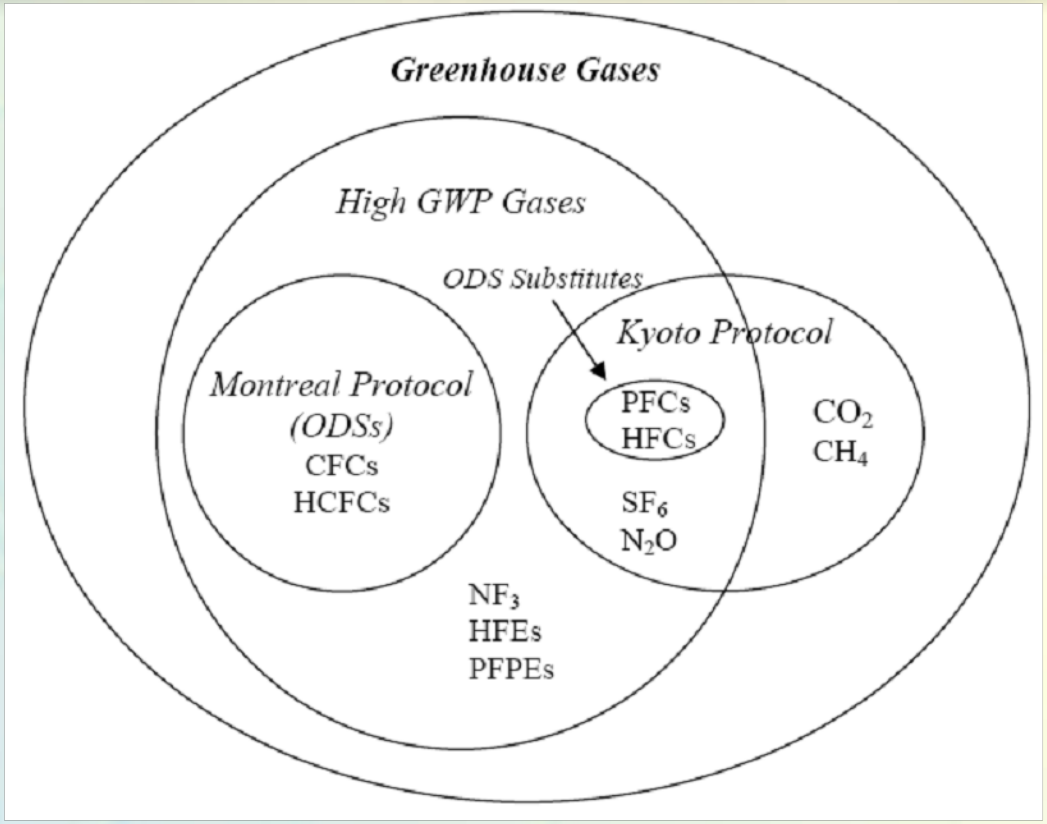
California Environmental Protection Agency
AIR RESOURCES BOARD

Outline

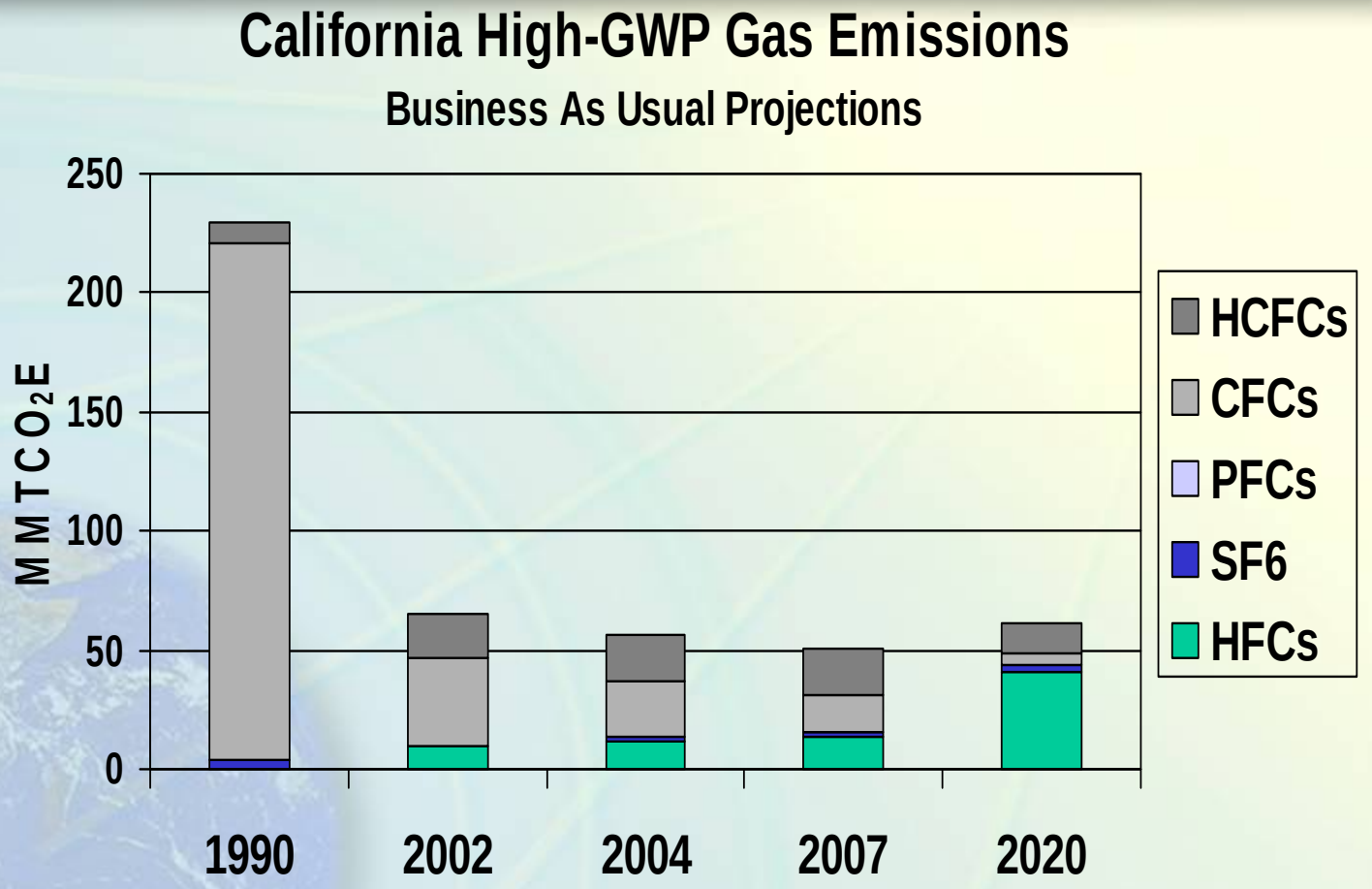
- What are high-GWP GHGs?
- Why pursue reduction of high-GWP GHGs?
- How are they used?
- High-GWP GHG inventory improvements and verification
- Concluding remarks

What are high-GWP GHGs?

- **Per AB 32, current CA inventory includes HFCs, PFCs, N_2O, and SF_6**
- **There are many other non-Kyoto substances that are potent GHGs**

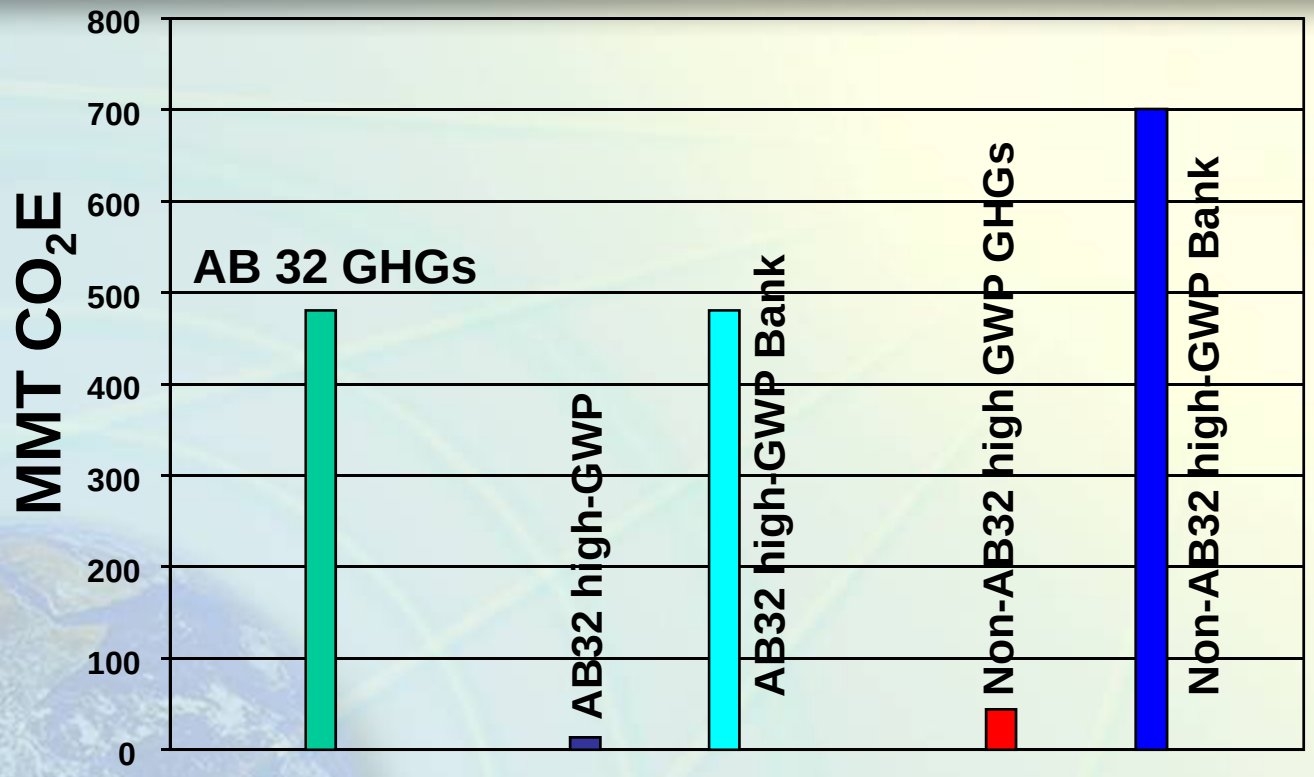


Why Target High-GWP GHGs?



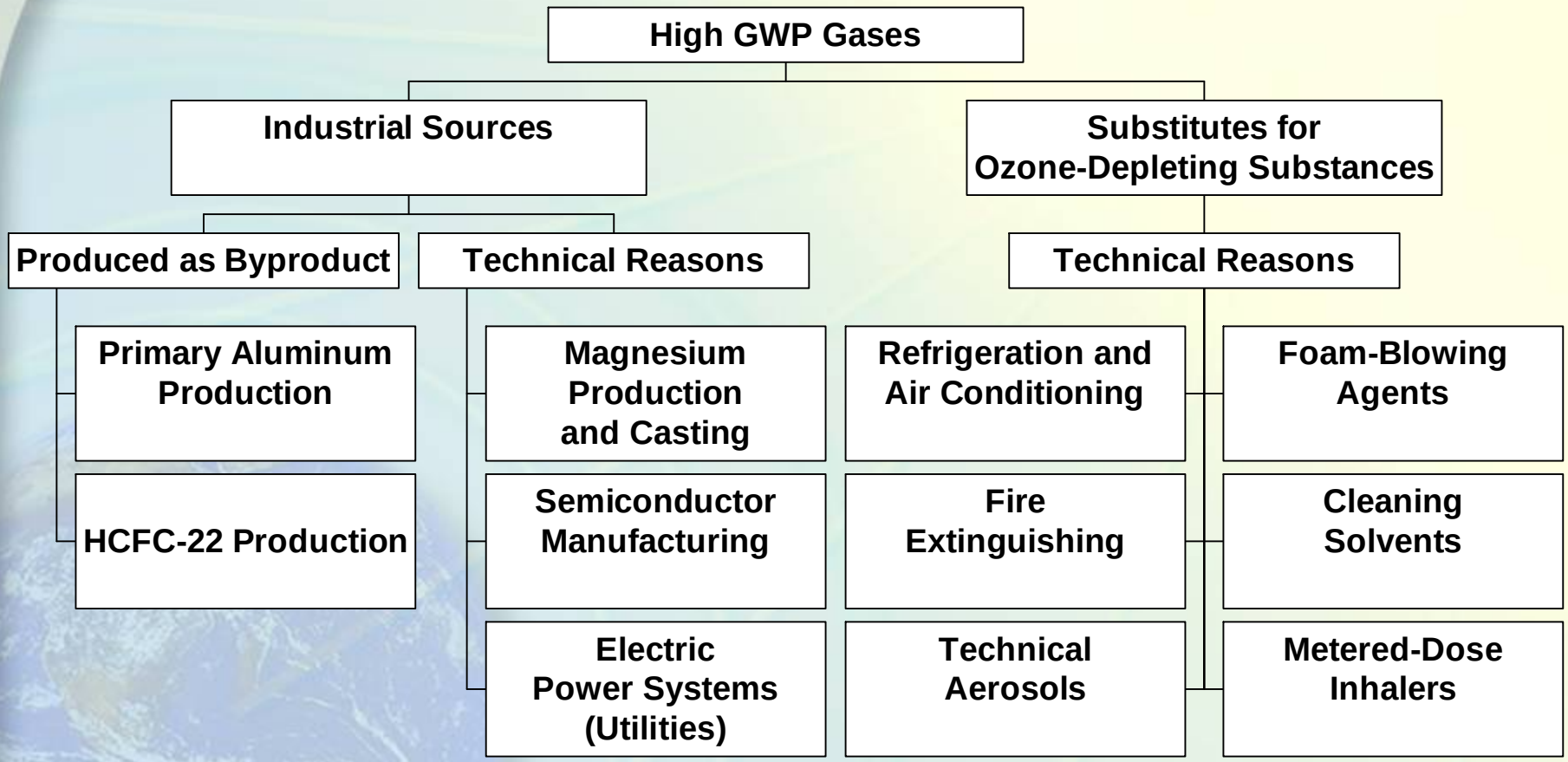
Very Rapid Growth of HFCs

Why Target High-GWP GHGs?



- **Large banks**
- **Low-hanging fruit opportunity**

Diverse End-use Application of High-GWP GHGs



What Sectors are Target for Early Action?

- Motor Vehicle AC

- Stationary Commercial Refrigeration & AC

- Insulating Foams

- SF6 (Non-electric, Non-semiconductor)

- Fire Suppression

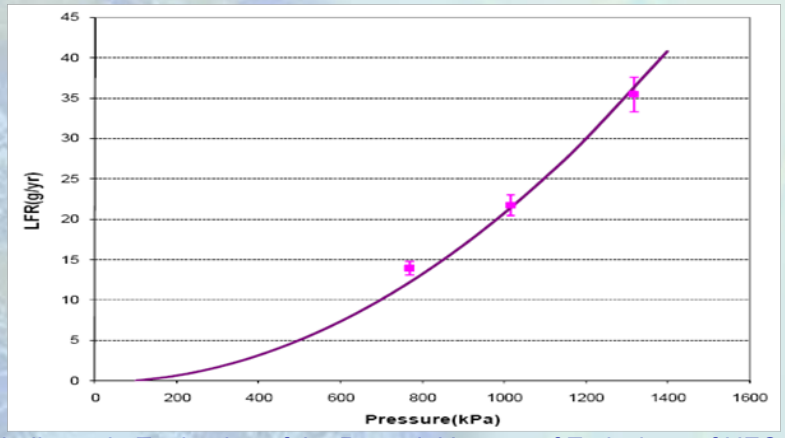
- Consumer Products

Motor Vehicle Air Conditioning

Motor Vehicle Air Conditioning

A MVAC System in Mini-SHED for Leak Testing

Measured Leak Flow Rate of a MVAC System



Impact

- Conventional MVACs are not hermetic. Refrigerant leaks naturally
- They require servicing
- Better technology can improve refrigerant containment
- Alternative low-GWP refrigerants nearing adoption by car makers

Ref: Clodic et al., Evaluation of the Potential Impact of Emissions of HFC-134a from Non-professional Servicing of Motor Vehicle Air Conditioning Systems, ARB Research Contract Draft Final Report, July, 2008

Motor Vehicle Air Conditioning

Background

- Total HFCs: ~13 MMTCO$_2$E
- HFC-134a: 2/3 of all HFCs
- Mobile AC: 60% of all HFC-134a
- MVAC: 3/4 of all mobile AC = ~3 MMTCO$_2$E

Motivation

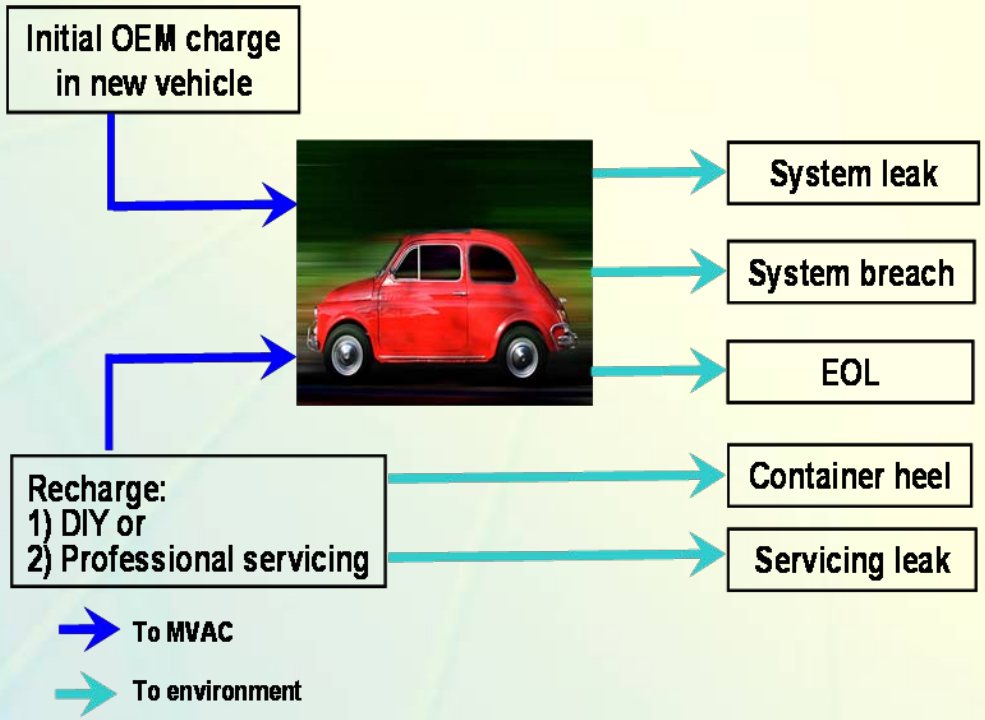
- AB 1493 drove 1st HFC-134a MVAC inventory
- AB 1493 inventory not broken down by usage modes

Methods

- Quantify usage ("mass in") by usage modes

Simple Mass Balance Model

Mass in = Mass out



Data Sources:

1) ARB Consumer Products Survey
2) Sales data
3) Industry survey
4) Extramural research/ARMINES, France/Clodic

Stationary Commercial Refrigeration and Air Conditioning

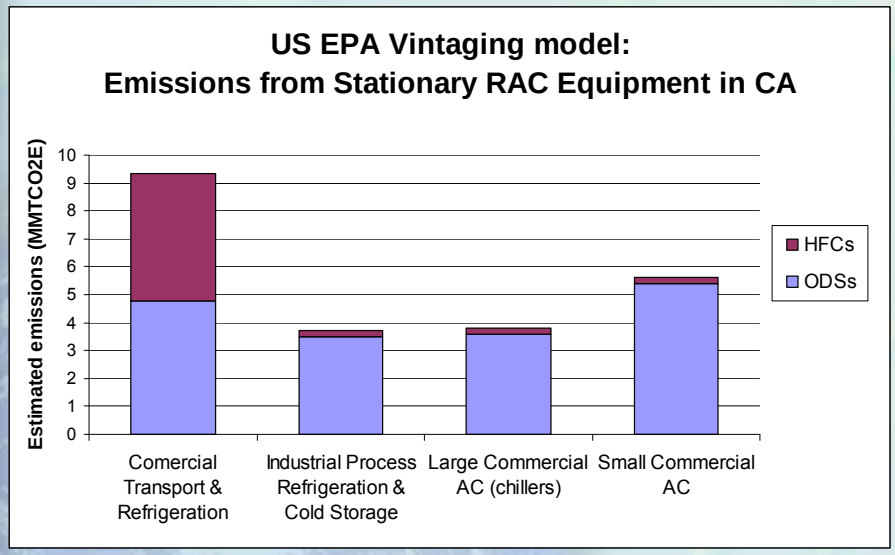
Stationary Commercial Refrigeration and Air Conditioning

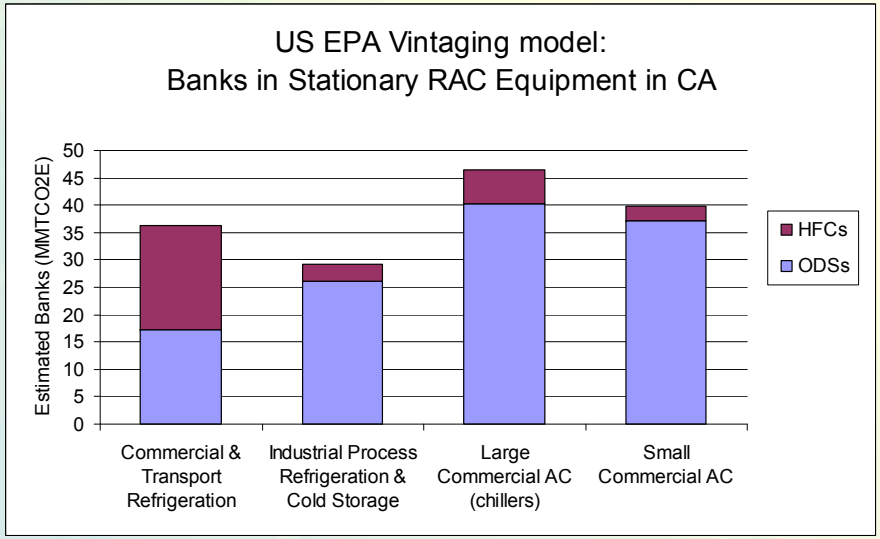
Significant source of High-GWP GHG emissions

US EPA Vintaging Model estimates extrapolated to CA:

~ 22 $MMTCO_2E$ emissions from stationary RAC equipment

~ 150 $MMTCO_2E$ in stationary RAC equipment banks

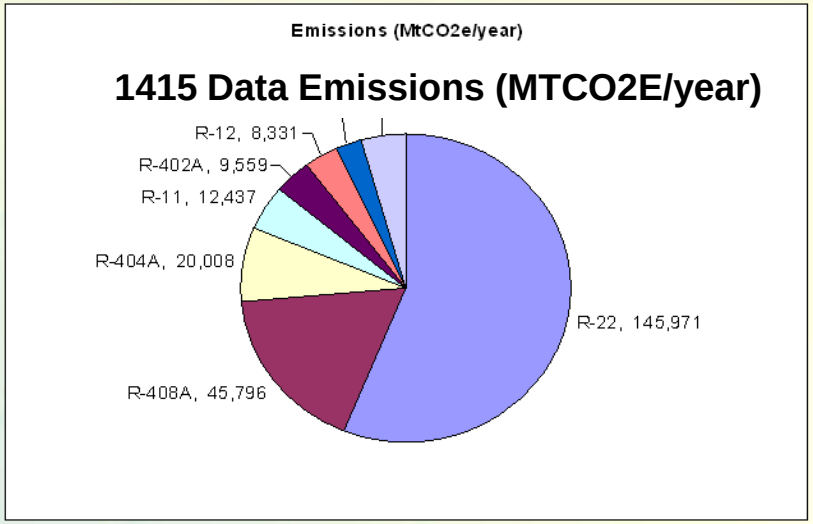




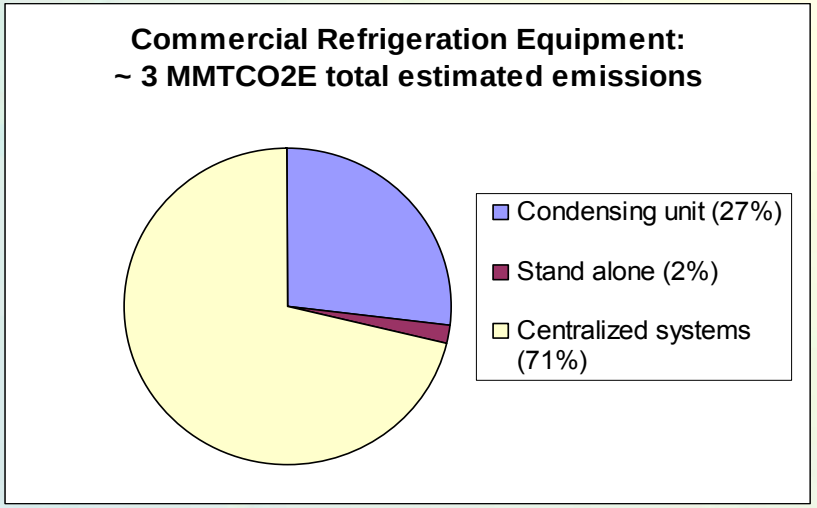
Stationary Commercial Refrigeration and Air Conditioning

Existing data sources

- **SCAQMD Rule 1415 dataset**
  - Facility # estimates
  - Leak rates
  - Charge sizes



- **ARMINES study**
  - Characterization of refrigeration use in food retail and industrial process
  - Emission and bank estimates for refrigeration and A/C equipment in CA



Stationary Commercial Refrigeration and Air Conditioning

Gaps in existing datasets:

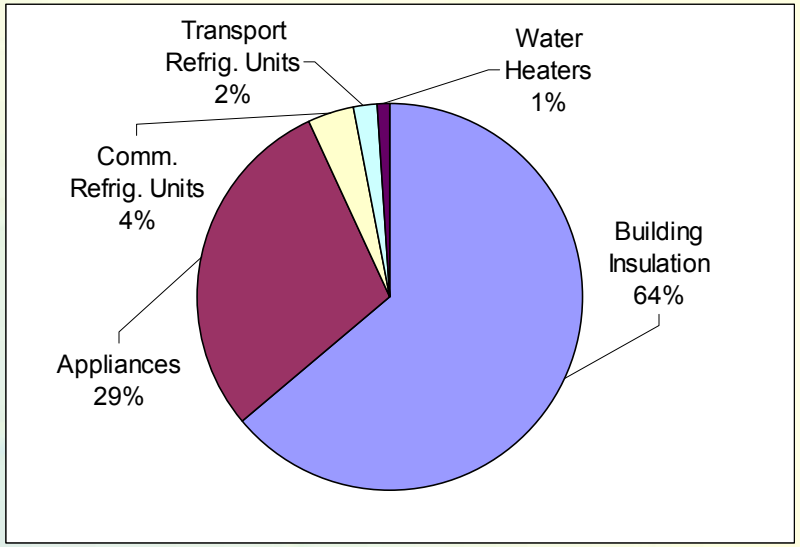
- **Office building inventory in CA**
  - Data from the Dept. of Energy CBECS report
- **Pattern of High-GWP refrigerant use in cold storage, food processing, and agricultural facilities**
  - ARB staff stakeholder survey
- **Characterization of A/C use by specific facility types in CA**
  - Obtain data from the CEC California End-Use Survey (in progress)
- **Additional leak rate estimates for refrigeration and A/C equipment**
  - 2006 IPCC report
  - 2006 Refrigeration, Air Conditioning and Heat Pump TOC UNEP report

Insulating Foams

Insulating Foams

- **Contains CFCs, HCFCs, HFCs**
- **Components**
  - Buildings
  - Appliances
  - Commercial Refrigeration Units
  - Transport Refrigeration Units
  - Water Heaters
- **Motivation for Inventory Research**
  - Potentially significant source of GHGs
  - National estimates from US EPA Vintaging Model, scaled to CA population. Does not reflect State's unique usage patterns
- **Methods**
  - Quantify usage by manufacturing, sales
  - Quantify disposal of foam

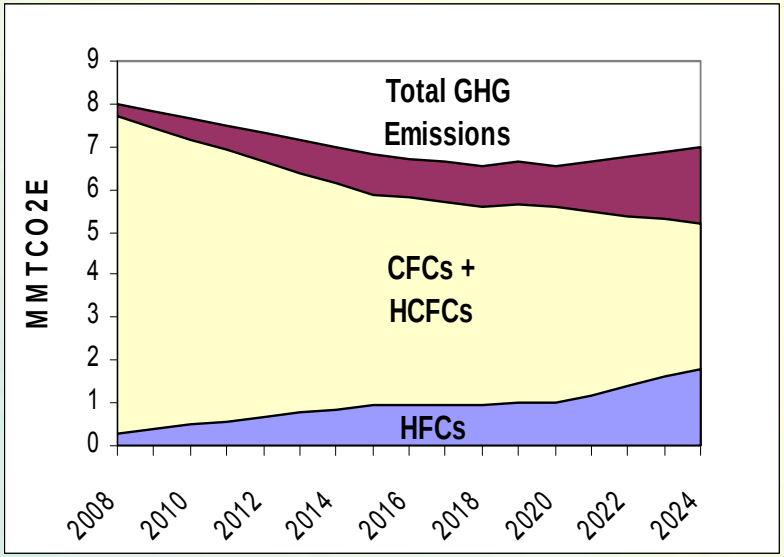
Components of Insulating Foam



Insulating Foams

- **Data Sources**
  - Sales data
  - Industry survey
  - Scrap recycling data
  - Construction & Demolition Debris data
  - ARB Research Contract (July 2008 - June 2010)
- **Preliminary Results**
  - 400 MMTCO$_2$E "Banked" Potential Emissions in existing foam in-use
  - 8-9 MMTCO$_2$E Annual Emissions in CA
  - HFC emissions increasing
- **Future Research Needs**
  - Quantify banks of existing foam in-use
  - Quantify end-of-life (EOL) emissions
  - Quantify emission reductions in landfilled foam occurring through: biological degradation; methane control systems

Est. Annual GHG Emissions in CA. from Insulating Foam



SF_6 from Non-electric and Non-semiconductor Applications

SF_6 from Non-electric and Non-semiconductor Applications

- **Components of the Source**
  - Magnesium casting
  - Tracer applications
  - Recreational & other uses (Magic tricks, products)
  - Medical uses
  - All are emissive uses
- **Motivation for these Inventory Efforts**
  - Inventory does not exist for the State
  - No national level inventory for most uses
  - Emissive uses of SF_6 to be covered by discrete early action to go to Board in early 2009
- **Methods and Data Sources for Estimating the Inventory**
  - ARB survey (Manufacturers, Distributors, Users)
  - Global and national data scaled to California
    - Sales to end-uses
    - National-level magnesium estimates
  - Draft regulatory language contains data gathering

Photos courtesy of 3M™

Fire Suppression

Fire Suppression

- **Overview**
  - High GWP and ODS in fire suppression systems
  - Halons: ODS and have high GWPs
    - Mainly in banks of in-place fire suppression systems
  - HFCs: In new systems and banks
- **Components of the Source**
  - Emissions from leakage, accidental discharge, and intentional discharge in fire events
- **Motivation for these Inventory Efforts**
  - State inventory based on national emission estimates scaled to California
    - Uncertainties in national inventory
  - California could differ in key assumptions
- **Methods and Data Sources for Estimating the Inventory**
  - Investigating methods for improving state level inventory
  - Will involve key stakeholders in inventory methodology development

Consumer Products

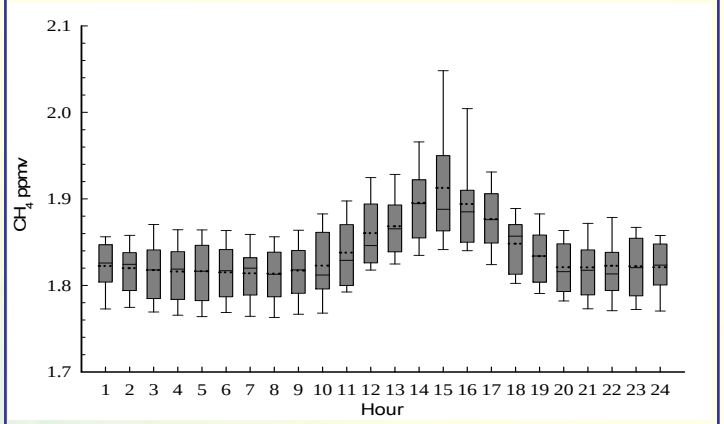
Consumer Products

- **Components of the Source**
  - HFC emissions from propellants used in Pressurized Gas Dusters, Tire Inflators, Defense Sprays, Signal Horns, Personal Care Products, and other products
- **Motivation for these Inventory Efforts**
  - Discrete Early Action Measure
  - Inventory for the State needs refinement / verification
- **Methods and Data Sources for Estimating the Inventory**
  - Manufacturer surveys of sales and formulation data
  - Internal research
- **Preliminary Results**
  - Staff in process of reviewing survey data
  - 0.25–0.5 MMTCO$_2$E per year

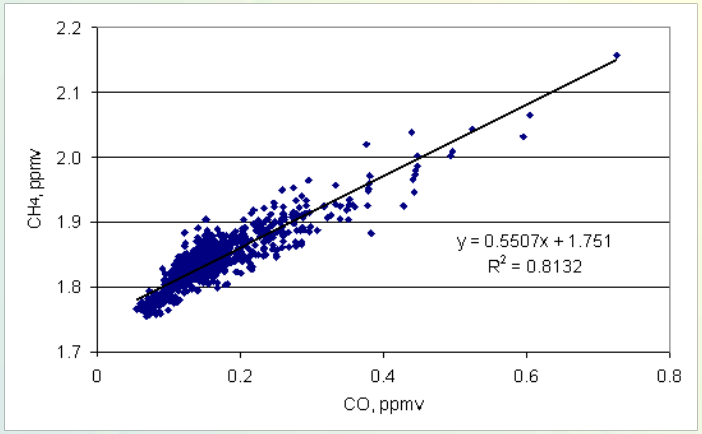
Inventory Verification: Ambient Measurements

- **Mt. Wilson Study**
  - Intensive measurements of high-GWP, CH_4, VOCs, and CO
  - Inferences of high-GWP and CH_4 inventories based on the ratio of high-GWP and CH_4 to CO
- **Establish Statewide CH_4 Monitoring Network**

Quartile Plot of CH_4 Concentrations and Diurnal Variation at Mt. Wilson



Correlation of CH_4 and CO Concentrations Measured at Mt. Wilson



Inventory Verification: Ambient Measurements

- **Aircraft Studies**
  - ARCTAS in 2008
  - CalNex in 2010

- **Mobile Platforms for GHG Measurements**
  - Two Mobile Monitoring Platforms under construction that will measure N_2O, CH_4, CO_2, CO, and black carbon from poorly characterized sources and investigate the existence of unknown sources
  - Transportable GC to identify sources of high-GWP GHGs in Los Angeles, CA

Concluding Remarks

- High-GWP GHGs used in various applications
- Emissions rapidly growing, having huge banks → great challenge as well as opportunities for CA's climate protections goals
- Application-specific and CA-specific inventory helpful in identifying mitigation strategies
- Detailed inventory unavailable or merely scaled down from national level by population
- Research being conducted at ARB to improve inventory
- Ambient monitoring studies being conducted at ARB to verify new inventory